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U.S. Environmental Protection Agency
Emergency Response Office
75 Hawthorne Street
San Francisco, California 94105

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Attention: K. Nelson, Project Officer

Subject: **Grey Eagle Mine Removal**

1. Introduction

On September 13, 1998, U.S. Environmental Protection Agency (USEPA) Federal On-scene Coordinator (FOSC) B. Mandel tasked the Superfund Technical Assessment and Response Team (START) to provide technical assistance for the short-term removal/remediation of the Grey Eagle Mine Tailings site. The removal action involved the abandoned mine tailings along Indian Creek, approximately five miles north of the town of Happy Camp, Siskiyou County, California (41° 51' 27" latitude, 123° 23' 54" longitude) . A previous START investigation in June, 1996 provided data on the soil and surface water conditions (technical direction document [TDD] T099603-0001, see Attachment A). In August 1998, START returned to Grey Eagle with FOSC B. Mandel at the request of the Karuk Tribe EPA representatives for an assessment of a possible emergency response action (TDD 09-98-0002, see Attachment B). For this TDD, START was tasked to: 1) Deploy data-logging water quality monitors in Indian Creek to evaluate effects from the response action; 2) Conduct real-time particulate air monitoring during excavation activities; 3) Provide geochemistry consulting as required.

1.1 Background

The Grey Eagle Mine is located approximately eight kilometers north of the town of Happy Camp, Siskiyou Co., California (Figure 1). According to USEPA files, the mine is currently inactive and owned by the Siskon Gold Corporation of Grass Valley, CA. Exploration and mining began in 1895; sulfide copper ores were mined sporadically through the early half of the twentieth century under several operators. From 1941 to 1945, the Grey Eagle Mining Company (a subsidiary of Newmont Mining Company) operated a deep-tunnel copper mine. The ore was milled on site, and the tailings were pumped to the tailings site at the mouth of Luther Gulch, along Indian Creek. Along with copper,

Figure 1: Grey Eagle Mine and Tailings site map.

byproducts of gold and silver were also extracted from the millings. There is no evidence of activity at the mine from 1945 until 1981; the mine was owned by the Standard Slag Company of Reno, Nevada during this time. The Noranda Mining Company reopened the Grey Eagle Mine, extracting gold and silver from 1981 through 1986.

The tailings pile appears to have been generated during the 1941 to 1945 period of mining, when millings were sent by flume down to the site for cyanide extraction. In about 1952, a depression of approximately 4.2×10^4 m^2 and 5 m deep (4.5×10^5 ft^2 area and 15 ft deep) was constructed in the tailings pile and utilized as a log pond by a saw mill which was operated on the site by the Willamette Lumber Company (Willamette) from 1945 to 1965. Croman Corporation owned the property from 1975 to 1990; Siskon Gold Co. owned the property from 1990 to 1996. There is no report of tailings having been dumped on the site during the mining activity in the 1980s.   The property is currently privately owned by B. McCoy, the former site caretaker.

Data from the 1996 assessment indicate that there is no residual cyanide from the extraction process which took place from 1941-1945; the main concerns at the tailings site are the heavy metal concentrations in the sulfide deposits and the acidic conditions caused by the oxidation of the sulfide phases present. The 1998 START assessment demonstrated that groundwater is present at depth in the tailings pile and that only the uppermost surface of the tailings were oxidized.

Figure 3: Trenching across the tailings pile. Note the yellow, oxidized tailings, as well as the dark, non-oxidized tailings. Photo by T.

1.2 Site Elements

The site includes the tailings pile, as well as surrounding areas affected by the tailings pile. A site map is presented in Figure 2.

1.2.1 The Tailings Pile

The tailings pile occupies the southern portion of the McCoy property, as well as a small corner of USFS land at the SE corner of the Site (Figure 2). The tailings pile is in excess of 330 m (~1000 ft, or about three football fields) long in the E-W direction, and 130 to 170 m (~400 to 500 ft) in the N-S direction. The tailings pile is at least 7 to 8 m (~ 20 to 25 ft) deep across most of its area and contains an estimated 360,000 m^3 (475,000 yd^3) of sulfide-rich material. The southern boundary of the tailings is typified by a 3-4 meter-high slope through which tailings can be identified to the base.

The surface of the tailings pile appears yellow-orange in color. Inspection of exposed areas reveals millimeter-scale laminae varying from yellow-orange to light grey in color (see Figures 3and 4). A white to yellow colored leachate salt may be observed both on the surface and some slopes of the tailings pile. The leachate forms a hard crust in some places and has a strong sulfur-like odor. Inspection of the leachate indicates that it consists of elemental sulfur and sulfosalts.

Figure 4: The tailings pile at the south western corner, along Indian Creek. Note the whitish leachate deposits, as well as the reddish

2.1.2 The Former Log Pond

The former log pond (Figure 5) was cut into the tailings and is bermed on the southern end by tailings. These tailings appear to be in place, as they exhibit the same horizontal laminae as the rest of the deposit. The excavation is floored by reddish-brown to yellowish brown soils and contains log fragments. Inspection of the log fragments reveals saw marks and other indications that this uppermost layer was deposited during the period from 1945 through 1965 when a saw mill operated on the property; this excavation was used as a saw mill pond during that time.

Figure 5: The log pond area before site work commenced. The photo is taken from the north western corner of the pond. The berm at the southern end is 2 to 3 meters high; the trees along the berm on the south eastern corner are 3 to 6 meters high.

The assessment by START in August 1998 concluded that the log pond was probably responsible for the existence of a perched groundwater zone found about 3 meters below the surface of the tailings in the pond area (see the 1998 START Assessment report). During the rainy season, the pond would partially fill with water, recharging the perched zone. This perched water is critical in the oxidation reactions and subsequent metal transport observed in the 1996 START report, where water pH was recorded as low as 2.5 and dissolved concentrations of Cr, Co, Cu, Fe, Ni, and Zn were abnormally high.

Figure 6: Acidic waters (pH = 6.2) seeping along the banks of Indian Creek. Water is migrating along terrace gravels which rest unconformably atop an aquiclude comprised of crystalline basement.

2.3 The Leachate Stream

A leachate stream is located within the stream channel between the tailings pile and Indian Creek (see Figure 2). The stream arises from artesian activity south of the tailings pile where water was observed seeping from several locations (Figure 6). The water in the leachate stream ranges from clear to a turbid, reddish-brown. The area around the stream has a slimy, reddish-brown discoloration and/or is coated with a white to yellow leachate salt similar to those observed on the tailings pile. These features were observed for the length of the leachate stream to where it merges with Indian Creek on Mr. S. Davis's property. The leachate stream is seasonally intermittent, and has changed its path several times over the past two years.

The leachate stream is thought to originate through artesian activity, largely from the perched water table observed in the 1998 START assessment. The leachate stream arises down gradient of the tailings pile, and is fed by several tributaries arising from the base of the tailings pile along its length. The lowest pH values, and the highest metals concentrations, were reported from samples taken from the leachate stream during the 1996 START investigation.

The leachate stream is intermittent and appears to have meandered over time. During the August, 1998 START assessment, the leachate stream was observed flowing from its origins to where the channel intersected Indian Creek. On September 25, 1998 when the downstream monitoring station was installed (see below), the leachate stream was not flowing into Indian Creek. It is assumed that the leachate stream was still draining into Indian Creek via ground flow. Discoloration of the rocks along the bank upstream of where the leachate stream intersects Indian Creek is evidence for substantial interaction of site-derived groundwater with Indian Creek. In the later days of the monitoring interval, the leachate stream was observed trickling into Indian Creek.

1.2.4 U.S. Forest Service Land

A small area of land belonging to the U.S. Forest Service is affected by mine tailings. The tailings here are not thick; excavations for the August 1998 START assessment indicate thicknesses ranging from 0.1 to 0.3 meter in this area. The fact that the tailings are underlain by a rather thick (1 - 2 meters depth) layer of wood debris led START to conclude that these tailings were not in place, but were moved to this site during a later period. The proximity of these tailings to the banks of Indian Creek was such that the tailings could be undercut and/or eroded during flood stages.

1.2.5 Indian Creek

Indian Creek (Figure 2) flows adjacent to the site in a SSE direction. Indian Creek meets at the town of Happy Camp with the Klamath River, which flows around the northwest region of the Klamath Range to the Pacific Ocean. Red staining occurs on the north bank of Indian Creek adjacent to the tailings pile site (Figures 7 and 8). These conditions worsen where the leachate stream comes in contact with Indian Creek, and persist several miles south to the town of Happy Camp, where the staining occurs on both sides of the creek.

The red staining observed on the banks is deposited colloidal iron, which precipitates when acidic, metal-bearing waters of the leachate stream come in contact with less acidic waters of Indian Creek. The precipitated iron oxide forms insoluble colloidal molecules, which flocculate and fall out of suspension.

Figure 7: Indian Creek along tailings pile site, looking upstream. Note the marked contrast between red-stained rocks on site side and clean rocks on the opposite bank.

Figure 8: Another view of the turbid conditions and staining on the banks of Indian Creek along the site.

According to the USFS, this type of iron floccules can drastically affect fish respiration, the health of fish eggs, and bottom-dwelling invertebrates (USFS Draft Report, February, 1996).

1.2.6 Oxidation in the Mine Tailings Pile

The August 1998 START assessment concluded that the low pH and turbid conditions at Indian Creek near the mine tailings was an indication that strongly reduced minerals in the tailings were slowly oxidizing. It was calculated that less than 10% of the tailings pile had oxidized, and further oxidation would continue for many years into the future. Also, the potential for a catastrophic release due to the undercutting of the tailings pile during flood stages of Indian Creek existed.

2.0 Removal Objectives

The objectives of the removal action are: 1) remove the mine tailings from the USFS property; 2) remove the southern berm of the log pond and re-grade the slope to two percent; 3) create a 1.5 % grade at the bottom of the log pond structure in order to provide adequate run off; 4) install rip-rap at the base of the tailings pile near Indian Creek to protect from erosion; and 5) cap the surface of the tailings with plastic, then native soil and vegetation to limit the infiltration of atmospheric oxygen into the tailings pile. All removed tailings were incorporated into the grading of the log pond, so no tailings were removed from the site.

The work was performed from September 21 through November 25. This removal/remediation was performed by the Emergency and Rapid Response Services (ERRS) contractor, CET Environmental Services, Inc. (CET).

3.0 START Monitoring Objectives

START monitoring activities were to occur during the first and last phases of activity, then as needed by the OSC. Monitoring was to include site perimeter air surveillance as well as stream water monitoring. Because no major effects on Indian Creek were observed during the first monitoring phase, the last phase was canceled by acting FOSC D. Suter.

The objective of the site perimeter air surveillance effort was to document airborne concentrations of particulates not otherwise classified (PNOCs) evolved as a result of the response activities. The monitoring approach provides data necessary to assess the effectiveness of on-site dust-suppression controls being utilized to minimize the impact to worker health and safety, as well as the surrounding environment during the response effort. Air monitoring took place from September 25 through October 3, 1998 and provides a reasonable average for site activities.

The objective of the stream water monitoring was to evaluate any effects of the response action on Indian Creek. The monitoring approach provides data necessary to evaluate changes in the water quality, with respect to an up-stream background monitoring point, in the leachate stream and down-stream of the tailings site. Significant deviations from normal stream conditions as defined by the background monitoring station placed upstream of the site would require changes in the response activities in order to mitigate further releases. Stream monitoring took place from September 25 through October 4, 1998 during the period in which site activity was concentrated along the banks of Indian Creek. This was done to monitor surface waters during the time of highest probability of impact.

Figure 9: Destruction of the southern berm of the log pond area. A Miniram aerosol monitor is mounted on the post in the foreground.

4.0 START Site Activities

CET mobilized to the site on September 21 and began setting up the command post. FOSC B. Mandell arrived on September 22. On September 24, 1998, START member B. Castellana mobilized to the town of Happy Camp, CA (formerly Murderer's Bar) and began site activities on September 25. START demobilized on October 5, 1998.

4.1 Deployment of Air Monitoring Equipment

Air monitoring was performed by continuous direct-reading instrument (DRI) data acquisition throughout the day-time work schedule. Monitoring duration and frequency were reevaluated and revised after review of collected data throughout the early phases of the project.

Two MIE Miniram Model PDM-3 direct light scattering aerosol monitors were utilized to determine fugitive dust emissions in the ambient air. Typically, a data-logging unit was sited in relation to the response work area and prevailing meteorological parameters (Figure 9). The

Figure 10: The YSI 6920 data-logging, multi-parameter sonde with YSI 610DM data interface unit stationed at the Downstream Location.

Miniram was placed down wind of the area of field activity, at no more than 50 meters distance. A second Miniram was placed in the cab area of at least one piece of heavy equipment to monitor operator exposure conditions.

4.2 Deployment of Water Quality Monitoring Equipment

4.2.1 24-hour Monitoring Stations

Water quality conditions in Indian Creek and the leachate stream were continuously monitored during the first ten days of the response activities. Three YSI-6920 data-logging, multi-parameter sondes were utilized (Figure 10), one at each of three locations along Indian Creek. A background measurement instrument was stationed about 100 to 200 meters upstream of the tailings site. A downstream station was placed about 20 meters downstream of the point where the leachate stream meets Indian Creek. A third unit was used as a site-specific monitor, measuring water parameters first near the site activities on the USFS land, then in the leachate stream at the easternmost (downstream) end of the tailings pile.

Data from the sondes were downloaded at the end of each day, or as needed, using a detachable data interface. The long battery life and memory of the YSI-6920 allowed for continuous (24 hours per day) monitoring for the duration of the program. The YSI-6920 was calibrated by the Purveyor (EnviroServices and Repair; see Attachment A for documentation); the manufacturer states that the instrument only needs to be calibrated “occasionally” (YSI 6920 user manual) and is meant to hold its calibration over prolonged use.

4.3 Hand-Held pH Meter Survey

Water quality data were supplemented by data from a hand-held pH meter (YSI-3560). Measurements were taken at various locations along the leachate stream and Indian Creek, as well as near the three data logging stations. The purpose of the hand-held unit was to increase the area of monitoring and acertain consistency between the data generated by the three data logging stations.

The YSI-3560 instrument was calibrated daily before use, and cal-checked after use, as well. The calibration was performed over three points (pH = 4, 7, and 10) using prepared buffer solutions. Calibration records may be found in the field notebook.

After the first day of collecting data with the upstream YSI-6920, it became clear that the station was too close to the site to provide viable background data. The YSI-3560 was used to survey up- and across-stream to identify a suitable location for the background location. The details of this survey are presented below in the "Monitoring Results" section of this document.

4.4 Mapping the Extent of Mine Tailings on the East Side of the Site

On September 26, 1998, FOSC B. Mandell tasked START member B. Castellana with mapping out the mine tailings on the southeastern side of the site, including the berm. The purpose was to estimate where the excavations would end in this area. The eastern berm, unlike the southern and western berm areas, was vegetated with trees and brush, which provided stabilization to the slope, as well as a wind break for Mr. McCoy's property. Mr. McCoy had requested that the EPA save as many trees in this area as possible.

The tailings were distinguished from the native soil largely by color: the tailings are yellow-orange with grey laminae, and the native soil is red-orange with gravel and boulder clasts. The top portion of the eastern berm is capped by two to three meters of native soil, which is underlain by laminated tailings. The tailings outcrop in the eastern side of the berm from about one-third the distance from the north end of the pond to almost all the way to the south end. The southeastern-most corner of the berm is composed entirely of native soil which is grey in color and finer grained than the red-orange soil.

It was observed that trees grew where the native soil was, but did not grow in the tailings. Moreover, root systems abruptly stopped or changed direction at the soil/tailings interface. The presence or absence of tailings could actually be mapped by the location of trees and other vegetation.

5.0 Monitoring Results

5.1 Air Monitoring for Dust Concentrations

Because the 1996 START assessment revealed high metals concentrations for soil samples taken in the log pond area, action levels for dust had to be calculated taking these figures into account (see site QASP in Attachment C). The only

Figure 11: Water truck performing on-site dust-control measures. The water truck was operated by ERRS personnel during most of the work day hours.

concentrations which caused any concern were the arsenic values, which lowered the eight-hour personal exposure limit (PEL) from 10 mg/m3 for particles not otherwise specified (PNOC; see 29 CFR Part 1910, subpart Z) to 9 mg/m3. Action levels were lowered from 5 to 4 mg/m3 based on these calculations. The results for dust monitoring are presented in table 1; at no time did dust concentrations exceed the site action level.

Figure 12: High-wind conditions during the afternoon of October 1, 1998. A dust monitor located on the slope near the shed in the right-center of the photograph recorded high incidental readings, but the daily time-weighted average for the day was well below

Downwind dust concentrations on the site varied as a function of wind speed, direction, and variability. Dust-supression efforts by CET included the use of a water truck at all times (Figure 11). The highest dust levels were recorded on September 27, when the downwind station read an 8-hour TWA of 0.83 mg/m3; during this day, CET operated two excavators less than 20 meters from the monitoring station. On the afternoon of October 1, 1998, a front moved through the area and wind speeds picked up significantly. In spite of visually high dust levels and some very high instantaneous readings, the daily TWA for the downwind station read 0.11 mg/m3 (Figure 12).

Figure 13: Cat excavator removing tailings and re-shaping the surface of the US Forest Service property on October 26, 1998.

On several days, dust monitors were placed in the cab areas of various equipment (Figures 13 - 15). Most of the equipment, including all the dumptrucks and one of the excavators, had enclosed cabins and air conditioning; readings for these pieces of equipment were predictably low. Equipment with no air conditioning and/or an open cab suffered higher dust readings; although none exceeded the action level.

Date	Downwind	Equipment	EQ Type
9/25/98	no data	0.55	Excavator
9/25/98	no data	0.48	Dump truck
9/26/98	0.05	0.30	Compactor
9/27/98	0.83	no data	
9/28/98	0.08	0.06	Dump truck
9/29/98	no data	0.29	Excavator
9/30/98	0.11	no data	
10/1/98	0.11	no data	
10/2/98	0.00 (SE corner)	no data	
10/2/98	0.14 (SW corner)	no data	
10/3/98	0.12	no data	

Table 1: Air monitoring results for dust; units are milligrams per cubic meter.

5.2 24-hour Stream Monitoring Data

The three YSI 6920 sondes were deployed at five locations over the monitoring interval from September 25 through October 4. These sites include Upstream Locations 1 and 2, the USFS Location, the Leachate Stream Location, and the Downstream Location. Temperature, pH, conductivity, turbidity, dissolved oxygen, and oxidation potential were measured every thirty minutes, 24 hours a day, at each of these locations while the units were in place. These data are presented in Attachment D of this report and graphically in Figures 16 and 18 through 22.

Temperature (T) was recorded in degrees centigrade (°C). Daily temperature fluctuations ranged from 11 to 18 °C on warm days to 10 to 14 °C on the colder days after the cold front of October 1. Inter-site temperature variations also resulted from water depth and stream flow at a given location.

Specific conductivity (Sp Cond) measures the electrical conductivity of water. Sp Cond was recorded in microsiemens per centimeter (ms/cm), where 1 ms/cm equals 1000 microOhms/cm. Specific conductivities for potable waters range from 0.05 to 1.5 ms/cm. Sp Cond may be considered an analog for dissolved electrolyte/metal concentrations in water. The solubility of these metals may change as a function of temperature and pH.

Figure 14: Deere excavator grading the southern berm area of the tailings pile. The original slope pilings have been sheared but are still visible along the contours of the pile. Note the silt fence at the base of the slope used to prevent tailings from entering the leachate stream below. Also note the stark contrast between oxidized (yellow-orange) and non-oxidized (black) tailings.

Dissolved oxygen (DO) was recorded in milligrams per liter (mg/l). Dissolved oxygen is a primary indication of the health of a stream environment. DO varies naturally as algae and other plant materials breath CO_2 while photosynthesizing during daylight hours, then O_2 at night. DO can be affected by abnormal conditions which spur chemical or biochemical reactions, such as the decay of organic matter or the precipitation of dissolved metals. A pertinent example of the latter process would be the precipitation of iron oxides as acidic waters come in contact with more basic waters (see START 1998 Assessment for a detailed explanation of the red-ox reactions associated with mine waste); the reaction can be described by the equation:

metal-rich acidic water + *basic stream water* W *iron floccules*

$$4Fe{+}3_{(aq)} + 3O_2 \quad + \quad nH_2\,O \quad \text{W} \quad 2Fe_2\,O_3{*}nH_2\,O_{(colloidal)}.$$

Oxidation-reduction potential (ORP) is derived from the DO, T, and pH; it is recorded in milliVolts (mV). ORP is the potential, or energy, required to change the oxidation state of a chemical component. Oxidation occurs when electrons are removed from the anion, increasing the valence state. Oxidizing conditions are reflected by higher readings in mV, and reducing conditions are reflected by lower numbers.

Water pH was measured at each location and corrected for temperature by the YSI 6920. Surface waters in Indian Creek above the mine tailings site range from 8.0 to 9.0, with diurnal cycles caused by

CO_2 respiration of photosynthesizing plants and algae. Other factors affecting the pH at Indian Creek include the addition of locally acidic ground waters of the Grey Eagle Mine tailings pile, the Grey Eagle Mine itself, and possibly regionally acidic groundwater (see text below).

Turbidity (Turb) was recorded in nephelometric turbidity units (NTU). Turbidity is measured as a function of the scattering of light as it passes through water and may be caused by the suspension of particulate mater (e.g. silt, clay, organic matter, and/or cholloidal material). Highly turbid conditions can drastically affect the health of a stream environment, affecting fish respiration, plant photosynthesis, and wildlife reproduction. Incidental turbidity anomalies can be caused by the disruption of stream bottom silt by wildlife, passers by, or the introduction of silt into the stream by construction activities. A progressive increase in turbidity would suggest a surge of sediment- or metal-laden waters either from the mine tailings area or the Grey Eagle Mine itself.

5.2.1 Upstream Location 1

Upstream Location 1 was chosen largely due to its accessibility. After collecting data for 24 hours, it was apparent that the upstream location was more acidic than the downstream location. Moreover, the parameters measured at this location do not exhibit the diurnal variations observed at the other locations (see discussion below on the cause of the diurnal effect). As a result, a new position for the upstream monitoring station had to be found.

Figure 15: Compacting the graded tailings along the northern end of the log pond. The open-cabbed compactor received some of the highest dust concentrations recorded, all well below the action

The data for Upstream Location 1 (Figure 16) indicate very little change in the stream conditions over a twenty-four hour period. Temperature (T) varied between 14 and 16 degrees centigrade, and the specific conductivity (Sp Cond) was invariantly 0.23 ms/cm. The dissolved oxygen (DO) varied from approximately 8.0 mg/l during daylight hours to 7.0mg/l during darkness; there was an inverse relationship between oxidation-reduction potential (ORP) and DO. The pH was invariantly 7.5 throughout the monitoring period; turbidity was uniformly low.

START performed a pH survey with a hand-held pH meter to identify a suitable position for the new upstream location. Figure 17 shows the area of Indian Creek west of the site, including Upstream Locations 1 and 2. The first transect across stream shows that pH values on the north bank are lower than on the south bank. This may be a result of acidic groundwater either from the site, Luther Gulch (where the Grey Eagle Mine is located), or regionally acidic waters of unknown origin. A second transect further up stream shows that the pH is higher in the center of the creek, and lower near both the southern and northern banks.

5.2.2 Upstream Location 2

The upstream monitoring station was moved after the first day of monitoring. There was no need to move the station again; subsequent upstream data collected from September 26 through October 4 were collected from "Upstream Location 2".

Data from Upstream Location 2 (Figure 18) exhibit predictable daily variations in most parameters. Temperature varied from 11 to 18 ^{o}C on warm days, and from 10 to 15 ^{o}C on cold days. Sp Cond varied on daily cycles from 16.5 to 17.5, with an anomalously low day on October 1; these values fall well within the range of potable waters. DO also exhibits a diurnal cycle between 9.0 and 10.5 mg/l; there is a slight increase in the average DO over the colder days from October 2 through October 4. The ORP values ranged from about 200 mV on warm days to about 350 mV on colder days. Diurnal pH values ranged from 8.5 during the day to 7.9 at night. Turbidity readings were generally low (below 5 NTU) during the monitoring period, except for a few anomalously high readings from September 27 through 29; the largest anomaly on September 27 corresponds to slight DO and ORP anomalies and could be due to road work occurring on Indian Creek Road to the North of the site.

5.2.3 Downstream Location Data

The downstream location was favorable throughout the monitoring interval; a complete set of downstream data were collected from this station from September 25 through October 4. T, Sp Cond, and pH exhibited diurnal variations and ranges similar to those observed in the background station (Upstream Location 2). This suggests that site activities did not significantly affect these parameters in waters of Indian Creek.

Figure 16: Data from Upstream Location 1 (9/25/98 through 9/26/98).

Figure 17: pH survey of the upstream area of the site to find a new Upstream (background) location for the site. Red dots indicate data points. Yellow dots indicate monitoring stations: A = Upstream Location 1, B = Upstream Location 2, and C = USFS location. The contours represent the pH profile in Indian

Creek interpreted from the known data points recorded on the morning of 9/26. The map area shown is indicated in Figure 2.

Figure 18: Water quality data from Upstream Location 2 (9/26 through 10/4/98).

Downstream location data (Figure 19) reflect the sum of conditions coming off the site during the early stages of activity. DO and ORP values for the downstream site were significantly lower (0.5 to 2 mg/l, and less than 150 mV) than the background site. Moreover, these parameters appeared to degrade throughout the monitoring interval. The initial lower values suggest that the lower DO and ORP values in the downstream waters of Indian Creek are an initial condition, likely due to the precipitation of metals along the site. The drop in these values over the monitoring interval may reflect either an increase in the effects from the site due to the removal activity or a decrease in the YSI 6920's ability to measure these parameters as the monitoring progressed.

Turbidity readings at the downstream site were highly variable, with several anomalies observed. The background value was consistently 0 NTU. The first major anomaly on September 27 corresponds to the large upstream event recorded on the same day. Other turbidity anomaly readings occurred throughout the monitoring period; many of these occurred at night and are probably the result of the movement of large animals (deer or bears) proximal to the monitoring station.

5.2.4 A Background vs. Downstream Comparison

A true indication of whether the site activities had any dramatic effect on the water conditions at Indian Creek is a comparison of the parameters in the background (upstream) location with those measured downstream. Figure 20 shows the five measured and one calculated parameters in the form Downstream divided by Upstream times one hundred (the Downstream values are calculated as a percentage of background).

Most parameters, with the exception of DO and ORP, do not vary significantly between downstream and background locations. Temperature variations between the two locations do not exceed 95%; while there may be some exothermic properties associated with the influx of acid/metal-bearing waters from the site, the temperature differences probably result from locality depth and stream flux. There is very little difference between Sp Cond measurements from both locations; the greatest measured difference (0.007 ms/cm) is less than five percent of the average value recorded at either location. The pH values observed at the downstream location vary less than 2% from the background values, with maximum differences at about 0.15. Turbidity does vary considerably between the background and downstream locations; these variations are largely incidental anomalies, with the background values for both locations remaining at zero.

The difference between DO concentrations between the background and downstream locations is significant. The difference between these stations is about seven to eight mg/l, about 20 - 25% of the upstream concentrations during the first few days of measurement. This difference increases to over 10 mg/l toward the end of the monitoring interval; DO in the downstream location plummeted to as low as 5% of background. This degradation of oxygen content is also reflected in the ORP curve.

It is suggested that the drop in DO and ORP at the downstream monitoring station over the monitoring interval is the result of renewed flow from the leachate stream observed over the course of the monitoring interval. An increase in the influx of metal-rich waters would decrease the available dissolved oxygen (as per the formula presented in section 5.2 of this report). The buffering capacity of Indian Creek water would maintain a relatively high pH, in spite of a higher influx of acidic water.

It is not clear whether site activities played a role in the rejuvenation of the leachate stream. While it is possible that disturbing the berm, regrading the slope, and/or watering for dust control could cause a change in the shape of the groundwater profile (no groundwater was actually encountered during the operation), it is just as likely that this rejuvenation is part of the normal fluctuation of the groundwater system. Because there are no data on the flow rates of the leachate stream, this cause is inconclusive.

5.2.4 The USFS Land Data

The site-specific station was located in Indian Creek, downstream from activities occurring on the USFS land, on September 25-26. Data from this monitoring event are similar to the average background activity observed in Upstream Location 2 for all parameters (figures 21 and 18, respectively). The high turbidity readings at the end of the monitoring period are the result of START personnel activities around the station. After the 24 hour period, excavation activities on the USFS land ceased, and the site-specific sonde was moved to a location in the leachate stream.

5.2.5 Leachate Stream Data

The site-specific sonde was located in the leachate stream at the eastern end of the tailings pile from September 26 through October 4; data are not available for the leachate stream for part of September 27-29, due to an equipment malfunction.

Figure 19: Water quality data from the Downstream Location (9/25 through 10/4/98).

*Figure 20: Plot of the percent difference between Upstream and Downstream data (Down/Up*100). The most notable difference recorded is in dissolved oxygen (DO), which dropped from 25% to 5% of background during the monitoring period.*

Figure 21: Water quality data for operations on the US Forest Service Land (9/25 through 9/26/98).

Figure 22: Water quality data for the Leachate Stream Location recorded 9/26 through 10/4/98. There is a gap in the data set from 9/27 through 9/28. Also note that the values for pH are likely erroneous.

Data collected from the Leachate Stream Location (Figure 22) are quite different from both the upstream and downstream locations. Daily temperatures ranged from 11 to 14 oC throughout the monitoring period. Sp Cond was significantly higher than the background site, with values ranging from 1.5 to 1.7 ms/cm. DO ranged from nearly 0 during the day to 6 mg/l at night. ORP exhibited similar variations to DO, ranging from 0 to 250 mV. The pH in the leachate stream was consistently acidic, ranging from 5.7 to 4.2. Turbidity exhibited some prolonged anomalies, some lasting several hours. While many of these anomalies occurred during times of site activities, others did not, suggesting that these values reflect the normal state of the leachate stream.

Some of the parameters observed in the leachate stream appear to degrade over the course of the monitoring period. DO, ORP, and pH are significantly different toward the end of the monitoring period, as compared with the beginning. On October 3, the water adjacent to the sonde was measured with a calibrated hand-held pH meter, which read 5.62, while the sonde read 4.5. Inpection of the sonde revealed a reddish slime covering all submerged surfaces, including the analytical probes. Some of this material was removed and the sonde read higher pH values over the next 24 hours. This material may have been biologically active, removing oxygen and respiring CO_2 into the area around the probes, yielding erroneous results.

6.0 Conclusions

Air and surface-water monitoring activities were conducted during the initial phases of the removal and remediation action at the mine tailings site of the Grey Eagle Mine (Figure 23). This monitoring was conducted to insure that site activities did not endanger the health and safety of both site workers and the general public, as well as insure the protection of the sensitive ecosystem of Indian Creek.

Figure 23: Site on 10/4/98. The photo is taken from approximately the same location as Figure 5.

Dust levels measured during site activities fell far below the action level of 4 mg/m^3. The action level was below the PNOC recommended action level (5 mg/m^3) due to unusually high level of arsenic in the tailings soil.

A hand-held pH meter survey indicates that the pH of Indian Creek waters can vary considerably from bank to bank, as well as upstream from the site. The pH values generally increased toward the center of the stream, as well as upstream. It is not clear whether the across-stream variation is the result of locally or regionally acidic ground waters, or biological variations. The upstream variation is assumed to be a result of acidic waters migrating off the mine tailings area.

Twenty-four hour water quality stations provided initial conditions indicating that the Grey Eagle mine tailings site had a detrimental effect on Indian Creek. Leachate stream waters were found to be mildly to strongly acidic, as opposed to the mildly basic background conditions of Indian Creek. Specific conductivity data indicate that waters of the leachate stream are higher in dissolved metals than Indian Creek. The leachate stream and associated ground waters flow unregulated into Indian Creek; the resulting metal precipitation has the net effect of reducing the dissolved oxygen content of the waters of Indian Creek, as well as creating turbid conditions downstream.

The station positioned downstream of the USFS land activities indicated that there were no adverse effects on Indian Creek from site activity during this phase of activity.

The downstream water quality station recorded that most parameters, with the exception of DO, did not change appreciably over the monitoring interval. While the initial conditions of downstream dissolved oxygen were shown to be about 21% of the background level (assumed to be the result of the pre-response site effluent), dissolved oxygen dropped to 5% of background toward the end of the monitoring phase. This may be the result of the observed increase in metal-rich waters flowing from the leachate stream toward the end of the monitoring phase.

This concludes the discussion of site activities performed by START at the Grey Eagle Mine Tailings site from 9/24/98 through 10/4/98. If you have any questions regarding this report, please feel free to contact this office.

Respectfully submitted,

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